

Appendix A

Data Collection Sheets

Appendix A includes:

- A.1 Workplace Practices Questionnaire
- A.2 Observer Data Sheet
- A.3 Facility Background Information Sheet
- A.4 Supplier Data Sheet

A.1 Workplace Practices Questionnaire



WORKPLACE PRACTICES QUESTIONNAIRE FOR THE MAKING HOLES CONDUCTIVE PROCESS

DESIGN FOR THE ENVIRONMENT (DfE) PRINTED WIRING BOARD PROJECT

This document is prepared by the University of Tennessee Center for Clean Products and Clean Technologies in Partnership with U.S. EPA Design for the Environment (DfE) Program, IPC, PWB manufacturers, and other DfE Partners

March 1995

****Note: This survey is not as long as it looks since you will only complete a part of it. This survey has 7 sections; however, we ask you to complete only sections 1,2,3 and the section that pertains to your making holes conductive (MHC) process.***

WORKPLACE PRACTICES QUESTIONNAIRE FOR THE MAKING HOLES CONDUCTIVE PROCESS

Design for the Environment Project

**PLEASE RETURN BY FRIDAY, MARCH 31, 1995 TO: IPC - ATTN: STAR
SUMMERFIELD, 7380 N. LINCOLN AVENUE, LINCOLNWOOD, IL 60646-1705**

DO NOT COMPLETE ALL SECTIONS OF THE QUESTIONNAIRE. The following explains which sections you should complete based on the type of making holes conductive (MHC) process used at your facility, provides background information on the questionnaire, and describes how the data will be handled to ensure confidentiality.

1. This questionnaire was prepared by the University of Tennessee Center for Clean Products and Clean Technologies in partnership with the EPA DfE Program, IPC, PWB manufacturers, and other members of the DfE PWB Industry Project.
2. For the purposes of this survey and the DfE Project, the "Making Holes Conductive (MHC)" process is defined as beginning after the desmear and etchback steps and ending prior to the dry film resist outer layer step (if required) and copper electroplating step.
3. Shaded sections of the questionnaire denote areas where responses to questions should be entered. Unshaded sections are instructions or keys required to answer the question.
4. Throughout the questionnaire, many questions request specific data, such as chemical volumes, the amount of water consumed by the MHC line or the characteristics of wastewater from the MHC line. If specific data are not readily available, estimates based on your knowledge of the process and the facility, are adequate. In cases where no data are available and there is no basis for an accurate estimate, mark your response as "ND."
5. Please complete Sections 1 through 3 of the questionnaire, regardless of which process is used at your facility to make drilled through-holes conductive prior to electroplating.
6. After completing Sections 1 through 3, please complete only the section(s) of the survey that corresponds to the MHC process(es) currently being operated at your facility, as listed below.

Electroless Copper.....Section 4
 Graphite-based.....Section 5
 Carbon-based.....Section 6
 Palladium-based.....Section 7

If the MHC process used at your facility is not listed, you have completed the questionnaire.

7. If your responses do not fit in the spaces provided, please photocopy the section to provide more space or use ordinary paper and mark the response with the section number to which it applies.
8. Appendix A contains the definitions of certain terms and acronyms used in the survey form.

9. **Confidentiality**

All information and data entered into this survey form are confidential. The sources of responses will not be known by IPC, University of Tennessee, EPA, or other project participants. Any use or publication of the data will not identify the names or locations of the respondent companies or the individuals completing the forms.

Please use the following procedures to ensure confidentiality:

- (1) Complete the survey form. Make a copy of the completed form and retain it for your records.
 - (2) Separate the facility and contact information page of the survey form from the remainder of the form. Place the facility and contact information into Envelope # 1 and seal the envelope.
 - (3) Place the remainder of the survey form plus any additional sheets or exposure monitoring data into Envelope # 2 and seal it.
 - (4) Place sealed envelopes # 1 and # 2 into the larger return envelope and mail it to IPC.
 - (5) When the package is received by IPC, only Envelope # 1 will be opened. IPC will place a code number on the outside of Envelope # 2 and forward it to the Center for Clean Products and Clean Technologies at the University of Tennessee. Envelope # 1 will not be sent to the University of Tennessee.
 - (6) Questions, clarifications, or requests for further information from the University of Tennessee will be relayed by code number to IPC, who will be able to contact the respondent. When it is determined that no further communications with respondents are necessary, the matrix of code numbers and respondents will be destroyed by IPC.
10. If you have any questions regarding the survey form, please contact Jack Geibig of the University of Tennessee Center for Clean Products and Clean Technologies at 615-974-6513 (e-mail: JGEIBIG@UTKVX.UTK.EDU).

<p>PLEASE RETURN BY FRIDAY, MARCH 31, 1995 TO: IPC - ATTN: STAR SUMMERFIELD, 7380 N. LINCOLN AVENUE, LINCOLNWOOD, IL 60646-1705 (PH: 708-677-2850 EXT. 347; FAX: 708-677-9570)</p>

Section 1. Facility Characterization

Estimate manufacturing data for the previous 12 month period or other convenient time period of 12 consecutive months (e.g., FY94). Only consider the portion of the facility dedicated to PWB manufacturing when entering employee and facility size data.

1.1 General Information

Size of portion of facility used for manufacturing PWBs:	sq.ft.	Number of days MHC line is in operation:	days/yr
Number of full-time equivalent employees (FTEs):		Total PWB panel sq. footage processed by the MHC process:	sq.ft./yr
Number of employee work days per year:	days/yr		

1.2 Facility Type

Type of PWB manufacturing facility (check one)	Independent		OEM	
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1.3 Process Type

Estimate the percentage of PWBs manufactured at your facility using the following methods for making holes conductive (MHC). Specify "other" entry.

Standard electroless copper	%
Palladium-based system	%
Carbon-based system	%
Graphite-based system	%
Electroless nickel	%
Other:	%
TOTAL	100%

1.4 General Process Line Data

Process Data	Shift			
	1	2	3	4
Number of hours per shift:				
Numbers of hours the MHC line is in operation per shift:				
Average square feet of PWB panel processed by the MHC line per shift:				

1.5 Process Area Employees

Complete the following table by indicating the number of employees of each type that perform work duties in the same process room as the MHC line for each shift and for what length of time. Report the number of hours per employee by either the month or the shift, whichever is appropriate for the worker category. Consider only workers who have regularly scheduled responsibilities physically within the process room. Specify "other" entry.

Type of Process Area Worker	Number of Employees per Shift				Hours per Shift per Employee	Hours per Month per Employee
	1	2	3	4	in Process Area (first shift)	in Process Area (first shift)
Line Operators					Hrs	Hrs
Lab Technicians					Hrs	Hrs
Maintenance Workers					Hrs	Hrs
Wastewater Treatment Operators					Hrs	Hrs
Supervisory Personnel					Hrs	Hrs
Contract workers					Hrs	Hrs
Other:					Hrs	Hrs
Other:					Hrs	Hrs

Section 2. General Process Data

The information in this section will be used to identify the physical parameters of the process equipment as well as any operating conditions common to the entire process line.

2.1 Process Parameters

MHC process line dimensions	Length:			ft.
	Width:			ft.
Average time for panel to complete process:		min.		
Size of the room containing the process:		sq.ft.		
Temperature of the process room:		°F		
Is the process area ventilated (circle one)?		Yes	No	
Air flow rate:		cu.ft./min.		
Type of ventilation? (Check one)	general		local	

2.2 General Water Usage

Amount of water used by the MHC process line when operating:	gal./day
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2.3 Wastewater Characterization

Estimate the average and maximum values for the wastewater from the making holes conductive line.

	AVERAGE	MAXIMUM
Flow	gpm	gpm
TDS	mg/l	mg/l
pH		
Cu	mg/l	mg/l

	AVERAGE	MAXIMUM
Pd	mg/l	mg/l
Sn	mg/l	mg/l
TSS	mg/l	mg/l
TTO	mg/l	mg/l

2.4 Wastewater Discharge and Sludge Data

Wastewater discharge type (check one)	Direct		Indirect		Zero	
Annual quantity of sludge generated:						
Percent solids of sludge						
Percentage of total quantity generated by the MHC process:						
Method of sludge recycle/disposal (see key at right)						

Methods of Sludge

Recycle/Disposal

[R] - Metals reclaimed

[D] - Stabilized and
landfilled

[O] - Other

2.5 Panel Rack Specifications - (non-conveyorized MHC process only)

Average number of panels per rack:			
Average space between panels in rack:		in.	
Average size of panel in rack:	Length	in.	Width
			in.

Section 3. Process Description

3.1 Process Schematic

Fill in the table below by identifying what type of making holes conductive process (e.g., electroless copper) your facility uses. Then, using the proper key at the bottom of the page, identify which letter corresponds with the first step in your process and write that letter in the first box (see example). Continue using the key to fill in boxes for each step in your process until your entire making holes conductive process is represented. If your process is not represented by a key below, complete the chart by writing in the name of each process step in your particular making holes conductive line. Finally, consult the process automation key at bottom right and enter the appropriate type of automation for the MHC process line. If the process is partially automated, enter the appropriate process automation letter for each step in the upper right-hand corner box (see example).

Type of Process (write in process name)		Process Automation Letter (see key below right)		Process Steps of Your Facility (begin here)	
		Ex. A	T	1.	
2.		3.	4.	5.	6.
7.		8.	9.	10.	11.
12.		13.	14.	15.	16.

ELECTROLESS COPPER PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	PROCESS AUTOMATION
[A] - Conditioner/Cleaner [B] - Micro Etch [C] - Pre-dip [D] - Activator/Catalyst [E] - Accelerator [F] - Electroless Copper [G] - Reducer/Neutralizer [H] - Anti-tarnish / Anti-oxidant [W] - Water rinse [O] - Other (specify step)	[A] - Cleaner/Conditioner [B] - Graphite [C] - Fixer [D] - Air Knife/Oven [E] - Post-clean Etch [F] - Anti-tarnish/ Anti-oxidant [W] - Water rinse [O] - Other (specify step)	[A] - Cleaner/Conditioner [B] - Graphite [C] - Fixer [D] - Air Knife/Oven [E] - Post-clean Etch [F] - Anti-tarnish/ Anti-oxidant [W] - Water rinse [O] - Other (specify step)	[A] - Cleaner/Conditioner [B] - Graphite [C] - Fixer [D] - Air Knife/Oven [E] - Post-clean Etch [F] - Anti-tarnish/ Anti-oxidant [W] - Water rinse [O] - Other (specify step)	PROCESS AUTOMATION TYPE OF PROCESS AUTOMATION FOR ENTIRE MHC PROCESS (Coconsult the key below) * If the MHC process is partially automated (option R) enter 'R' on above line. Then, for each process step in chart above, consult the key below and enter the appropriate process automation letter in the box located in the upper right-hand corner of each process step (see example). Process Automation Key [P] - Automated non-conveyorized [S] - Manually controlled hoist [Q] - Automated conveyorized [T] - Manual (no automation) [R] - Partially automated * [V] - Other (specify)

3.2 Rinse Bath Water Usage

Consult the process schematic in Section 3.1 to obtain the process step numbers associated with each of the water rinse baths present. Enter, in the table below, the process step number along with the flow control and flow rate data requested for each water rinse bath. If the water rinse bath is part of a cascade, you need only report the daily water flow rate of one bath in the cascade.

Process Step Number ^a	Flow Control ^b	Daily Water Flow Rate ^c	Cascade Water Process Steps ^d
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	

^a **Process Step Number** - Consult the process schematic in question 4.1 and enter the process step number of the specific water rinse tank.

^b **Flow Control** - Consult key at right and enter the letter for the flow control method used for that specific rinse bath.

^c **Daily Water Flow Rate** - Enter the average daily flow rate for the specific water rinse tank.

^d **Cascade Water Process Steps** - Enter the process step number for each water rinse tank in cascade with the present tank.

Flow Control Methods Key

[C] - Conductivity meter
 [P] - PH meter
 [V] - Operator control valve
 [R] - Flow restricter
 [N] - None (continuous flow)
 [O] - Other (explain)

3.3 Rack Cleaning - (non-conveyorized MHC process only)

Complete the following section by using the keys to the right of the table to identify the rack cleaning process used.

Frequency of cleaning:	
Number of personnel involved:	
Personal protective equipment (see key at right):	
Rack cleaning method used (see key at right):	
*If the above answer is [C], also enter the process step number from the process schematic (section 3.1) and do not complete section 3.4 below.	
Average time required to chemically clean rack (if applicable):	min.
Cleaning schedule (see key at right):	
Is rack cleaning attended (circle one)	Yes No

Personal Protective Equipment Key

[E] - Eye protection [G] - Gloves
 [L] - Labcoat/sleeved garment [A] - Apron
 [R] - Respiratory protection [B] - Boots
 [Z] - All except Respiratory protection [N] - None

Rack Cleaning Methods Key

[C] - Chemical bath on making holes conductive line
 [D] - Chemical bath on another line
 [T] - Temporary chemical bath
 [S] - Manual scrubbing with chemical
 [M] - Non-chemical cleaning
 [N] - None

Rack Cleaning Schedule

[A] - After hours
 [L] - During operating hours - in MHC process room
 [M] - During operating hours - outside MHC process room

APPENDIX A

3.4 Rack Cleaning Chemical Composition (non-conveyorized MHC process only)

Chemical Name	Conc.	Volume
		gal.
		gal.
		gal.

3.5 Conveyor Equipment Cleaning

Complete the following table on conveyorized equipment cleaning in the MHC process line by providing the information requested for each cleaning operation performed. If more space is needed or more than two cleaning operations occur, report them on a separate sheet of paper.

Equipment Cleaning Data	Cleaning Operation No. 1	Cleaning Operation No. 2	Personal Protective Equipment Key
Description of cleaning operation: (briefly describe equip. cleaned)			[E] - Eye protection
Process steps affected ^a			[G] - Gloves
Frequency of cleaning:			[L] - Labcoat/sleeved garment
Duration of cleaning:	min.	min.	[A] - Apron
Number of personnel involved:			[R] - Respiratory protection
Personal protective equipment (see key at right):			[B] - boots
Cleaning method used (see key at right):			[Z] - All except Respiratory protection
Cleaning chemical used ^b			[N] - None

Personal Protective

Equipment Key

[E] - Eye protection
 [G] - Gloves
 [L] - Labcoat/sleeved garment
 [A] - Apron
 [R] - Respiratory protection
 [B] - boots
 [Z] - All except Respiratory protection
 [N] - None

Conveyor Cleaning

Methods Key

[C] - Chemical rinsing or soaking
 [S] - Manual scrubbing with chemical
 [M] - Non-chemical cleaning
 [N] - None

^a **Process Steps Affected** - Consult the process schematic from section 4.1 and enter the process step numbers of the specific steps affected by the cleaning operation.

^b **Cleaning Chemical Used** - Enter the name of the chemical or chemical product (or bath type, if applicable) used in the specific cleaning operation.

3.6 Filter Replacement

Complete the following table on filter replacement in the MHC process line by providing the information requested for each set of filters replaced.

Replacement Information	Filter Assembly No. 1	Filter Assembly No. 2	Filter Assembly No. 3
Bath filtered (enter process step from 3.1):			
Frequency of replacement:			
Duration of replacement:	min.	min.	min.
Number of personnel involved:			
Personal protective equipment (see key below):			
Type of filter (see key below):			
Number of filters changed in assembly:			
Area of filter:	sq. in.	sq. in.	sq. in.

Personal Protective Equipment Key

[E] - Eye protection
 [L] - Labcoat/sleeved garment
 [R] - Respiratory protection
 [Z] - All except respiratory protection

[G] - Gloves
 [A] - Apron
 [B] - Boots
 [N] - None

Filter Type Key

[B] - Bag Filter
 [O] - Other (specify)

3.7 Process History

Complete the table below by indicating what making holes conductive process(es) your facility has employed in the past. Briefly explain the reasons for the process change and summarize how the change has had an affect upon production.

FORMER MAKING HOLES CONDUCTIVE PROCESS	DATE OF CHANGE TO CURRENT PROCESS
ELECTROLESS COPPER	
PALLADIUM-BASED	
GRAPHITE-BASED	
CARBON-BASED	
COPPER SEED	
ELECTROLESS NICKEL	
OTHER (specify)	

REASONS FOR CHANGE AND RESULTS		
Reason (see key)		Result (see key)
	Water Consumption	
	Process Cycle-time	
	Cost	
	Worker Exposure	
	Performance	
	Customer Acceptance	
	Product Quality	
	Process Maintenance	
	Other:	
	Other:	
	Other:	

Reasons

[X] - Mark all of the selections that apply

Results of Change

[B] - Better
[W] - Worse
[N] - No change

The remainder of the survey is dedicated to questions that are strictly specific to the type of making holes conductive process operated at your facility. **You should complete only the section(s) of the survey that corresponds to the MHC process(es) that is currently being operated.**

Select the making holes conductive process(es) that your facility currently operates and complete only the section(s) listed. If your process is not listed, then you have completed the questionnaire.

Electroless Copper Section 4 (pgs. 9-17)
Graphite-Based..... Section 5 (pgs. 19-26)
Carbon-Based..... Section 6 (pgs. 27-34)
Palladium-Based..... Section 7 (pgs. 35-43)

Section 4. Electroless Copper Process

The information requested below will allow us to generate an exposure assessment and risk characterization profile for each of the following baths and the associated activities involved in the operation and upkeep of the electroless copper process.

NOTE: You need to complete this section only if your facility uses an electroless copper process for making the holes conductive during the PWB manufacturing process.

4.1 Physical, Process, and Operating Conditions

Complete the table below by entering the data requested for each specific type of chemical bath listed. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH	PHYSICAL DATA			PROCESSING DATA		OPERATING CONDITIONS		
	LENGTH (inches)	WIDTH (inches)	NOMINAL VOLUME	IMMERSION ^a (seconds)	DRIP TIME ^b (seconds)	TEMP °F	AGITATION ^c	VAPOR CONTROL ^d
CLEANER/ CONDITIONER	in.	in.	gal.	sec.	sec.	°F		
MICRO-ETCH	in.	in.	gal.	sec.	sec.	°F		
PRE-DIP	in.	in.	gal.	sec.	sec.	°F		
ACTIVATOR/ CATALYST	in.	in.	gal.	sec.	sec.	°F		
ACCELERATOR	in.	in.	gal.	sec.	sec.	°F		
ELECTROLESS COPPER	in.	in.	gal.	sec.	sec.	°F		
REDUCER/ NEUTRALIZER	in.	in.	gal.	sec.	sec.	°F		
ANTI-TARNISH/ ANTI-OXIDANT	in.	in.	gal.	sec.	sec.	°F		
OTHER (specify)	in.	in.	gal.	sec.	sec.	°F		

^a **Immersion Time** - Enter the average elapsed time a rack of panels is immersed in the specific process bath.

^b **Drip Time** - Enter the average elapsed time that a rack of panels is allowed to hang above the specific bath to allow chemical drainage from panels.

^c **Agitation** - Consult the key at right and enter the letter for the agitation method used in the specific chemical bath.

^d **Vapor Control** - Consult key at right and enter the letter of the vapor control method used for that specific chemical bath.

Agitation Methods Key

[P] - Panel agitation
[F] - Fluid circulation pump
[A] - Air sparge
[O] - Other (explain)

Vapor Control Methods Key

[P] - Push-Pull
[C] - Bath cover (when not in use)
[B] - Plastic balls (floating)
[E] - Fully enclosed
[O] - Other (explain)

4.2 Initial Chemical Bath Make-Up Composition

Complete the chart below for each chemical component of the bath type listed. Provide the manufacturer name if the chemical used is known only by trade name. If more room is needed, please attach another sheet with the additional information. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED ^c (gallons)
CLEANER/ CONDITIONER	1.					
	2.					
	3.					
	4.					
MICRO-ETCH	1.					
	2.					
	3.					
	4.					
PRE-DIP	1.					
	2.					
	3.					
	4.					
ACTIVATOR/ CATALYST	1.					
	2.					
	3.					
	4.					
ACCELERATOR	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

APPENDIX A

4.2 Initial Chemical Bath make-Up Composition - CONTINUED

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED^c (gallons)
ELECTROLESS COPPER	1.					
	2.					
	3.					
	4.					
REDUCER/ NEUTRALIZER	1.					
	2.					
	3.					
	4.					
ANTI-TARNISH/ ANTI-OXIDANT	1.					
	2.					
	3.					
	4.					
OTHER (specify)	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** Enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

4.3 Chemical Bath Replacement

Complete the chart below by providing information on the process of replacing, treating, and disposing of a spent chemical bath.

BATH TYPE	CRITERIA FOR REPLACEMENT ^a	FREQUENCY ^b	DURATION OF REPLACEMENT PROCEDURE ^c	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^d	ON-SITE METHOD OF TREATMENT OR DISPOSAL ^e	ANNUAL VOLUME TREATED OR DISPOSED ^f	OFF-SITE METHOD OF TREATMENT OR DISPOSAL ^e
CLEANER/ CONDITIONER								
MICRO-ETCH								
PRE-DIP								
ACTIVATOR/ CATALYST								
ACCELERATOR								
ELECTROLESS COPPER								
REDUCER/ NEUTRALIZER								
ANTI-TARNISH/ ANTI-OXIDANT								
OTHER (specify)								

^a **Criteria for Replacement** - Consult the key at right and enter the letter for the criteria typically used to determine when bath replacement is necessary.

^b **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^c **Duration of Replacement** - Enter the elapsed time from the beginning of bath removal until the replacement bath is finished.

^d **Personal Protective Equip.** - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

^e **Methods of Treatment or Disposal** - Consult keys at right and enter the letter of the method used.

^f **Annual Volume Treated or Disposed** - Enter the yearly amount of the specific bath treated or disposed.

On-Site Method of Treatment or Disposal

[P] - Precipitation pretreatment on-site
 [N] - PH neutralization pretreatment on-site
 [S] - Disposed directly to sewer with no treatment
 [D] - Drummed for off-site treatment or disposal
 [R] - Recycled on-site
 [O] - Other (specify)

Off-Site Method of Treatment or Disposal

[R] - Sent to recycle
 [P] - Discharged to POTW
 [O] - Other

Criteria for Bath Replacement

[S] - Statistical process control [T] - Time
 [P] - Panel sq. ft. processed [O] - Other
 [C] - Chemical testing (Specify)

Personal Protective Equipment

[E] - Eye protection [G] - Gloves
 [L] - Labcoat/sleeved garment [A] - Apron
 [R] - Respiratory protection [B] - Boots
 [Z] - All except respiratory protection [N] - None

APPENDIX A

4.4 Chemical Handling Activities: Chemical Bath Replacement

Complete the table below by indicating the options your facility uses to replace each type of spent chemical bath. **If the same options are used to replace each of the various chemical baths, enter “ALL” as the type of bath and fill out only one table.** Otherwise, please photocopy and attach additional charts, as necessary.

TYPES OF BATHS ^a

REMOVAL OF SPENT BATH			CLEANING OF EQUIPMENT			NEW BATH MAKE-UP		
Method of Removing Spent Bath	Pump:		Tank Cleaning Method	Chemical flush:		Chemical Retrieval from Stock into Container	Pump:	
	Siphon:			Hand scrub:			Pour:	
	Drain/spigot:			Other (specify):			Scoop (solid):	
	Other (specify):						Other (specify):	
Remove Spent Bath	Directly to wastewater treatment:		CHEMICALS USED IN CHEMICAL FLUSH			Container Type	Open-top container:	
	Directly to sewer:						Closed-top container:	
	To open-top container:		Chemical	Gallons Per Year			Safety container:	
	To closed-top container:						Other (specify):	

^a **Type of Baths** - Enter the types of baths where the activities are used. If the chemical handling activities are the same for each bath type, enter 'ALL.'

4.5 Chemical Bath Sampling

Provide information on the chemical bath sampling procedures used in your facility. Duration of sampling and personnel involved should include only the portion of the testing procedure involving the manual sampling of the chemical baths, not automated sampling or the testing that may occur in another part of the facility, such as the lab.

BATH TYPE	TYPE OF SAMPLING ^a	FREQUENCY ^b	DURATION OF SAMPLING ^c	NO. OF PEOPLE ^d	PROTECTIVE EQUIPMENT ^e
CLEANER/ CONDITIONER			min.		
MICRO-ETCH			min.		
PRE-DIP			min.		
ACTIVATOR/ CATALYST			min.		
ACCELERATOR			min.		
ELECTROLESS COPPER			min.		
REDUCER/ NEUTRALIZER			min.		
ANTI-TARNISH/ ANTI-OXIDANT			min.		
OTHER (specify)			min.		

^a **Type of Sampling** - Consult the key at right and enter the type of sampling performed on the specific chemical bath.

^b **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. processed between samples. Clearly specify units (e.g., hours, square feet, etc.).

^c **Duration of Sampling** - Enter the average time for manually taking a sample from the specific chemical tank. Consider only time spent at the chemical bath..

^d **Number of People** - Enter the number of people actually involved in manually taking the chemical samples. Exclude people doing the testing but not the sampling.

^e **Personal Protective Equipment** - Consult key at right and enter the letters for all protective equipment worn by the people performing the chemical sampling.

Type of Sampling Key

[A] - Automated sampling [B] - Both
[M] - Manual sampling [N] - None

Personal Protective Equipment Key

[E] - Eye protection [G] - Gloves
[L] - Labcoat/sleeved garment [A] - Apron
[R] - Respiratory protection [B] - Boots
[Z] - All except respiratory protection [N] - None

4.6 Chemical Handling Activities: Chemical Sampling

Complete the table below by indicating what method your facility uses to manually collect bath samples and the type of container used.

Method of Obtaining Samples	Drain/Spigot:	
	Pipette:	
	Ladle:	
	Other (specify):	
Chemical Sample Container	Open-top container:	
	Closed-top container:	

APPENDIX A

4.7 Chemical Bath Additions

Complete the following chart detailing the typical chemical additions that are made to maintain the chemical balance of each specific process baths. If more than four chemicals are added to a specific bath, attach another sheet with the additional information. If chemical additions to a bath are made automatically, do not complete the last three columns for that bath. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
CLEANER/ CONDITIONER	1.						min.		
	2.								
	3.								
	4.								
MICRO-ETCH	1.						min.		
	2.								
	3.								
	4.								
PRE-DIP	1.						min.		
	2.								
	3.								
	4.								
ACTIVATOR/ CATALYST	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.)

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/liter, etc.) of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition

Method Key

[A] - Automatic *

[M] - Manual

*** If additions are automatic [A] then do not complete the last 3 columns**

Personal Protective

Equipment Key

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory Protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

4.7 Chemical Bath Additions - CONTINUED

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
ACCELERATOR	1.						min.		
	2.								
	3.								
	4.								
ELECTROLESS COPPER	1.						min.		
	2.								
	3.								
	4.								
REDUCER/NEUTRALIZER	1.						min.		
	2.								
	3.								
	4.								
ANTI-TARNISH/ANTI-OXIDANT	1.						min.		
	2.								
	3.								
	4.								
OTHER (specify)	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.).

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/litre, etc.) Of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition Method Key

[A] - Automatic *
[M] - Manual

* If additions are automatic [A] then do not complete the last 3 columns

Personal Protective Equipment Key

[E] - Eye protection
[L] - Labcoat/sleeved garment
[R] - Respiratory protection
[Z] - All except respiratory protection
[G] - Gloves
[A] - Apron
[B] - Boots
[N] - None

4.8 Chemical Handling Activities: Chemical Additions

Complete the following table by indicating the methods your facility uses while performing chemical additions.

ACTIVITY	OPTIONS	
Chemical Retrieval from Stock into Container	Pump:	
	Pour:	
	Scoop (solid):	
	Other (specify):	
Container	Open-top container:	
	Closed-top container:	
	Safety container:	
	Other (specify):	
Method of Chemical Addition	Pour directly into tank:	
	Stir into tank:	
	Pour into automated chemical addition system:	
	Other (specify):	

4.9 Other Bath Related Activities

Complete the following table for any other bath related activities that your facility engages in.

BATH TYPE	TYPE OF ACTIVITY (describe)	FREQUENCY ^a	DURATION OF ACTIVITY ^b	NO. OF PEOPLE	PROTECTIVE EQUIPMENT ^c
CLEANER/ CONDITIONER					
MICRO-ETCH					
PRE-DIP					
ACTIVATOR/ CATALYST					
ACCELERATOR					
ELECTROLESS COPPER					
REDUCER/ NEUTRALIZER					
ANTI-TARNISH/ ANTI-OXIDANT					
OTHER (specify)					

^a **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. Processed since the last time the activity was performed. Clearly specify units (e.g., hours, square feet, etc.)

^b **Duration of Activity** - Enter the average time for performing the specified activity. Clearly specify units.

^c **Personal Protective Equipment** - Consult key on the previous page and enter the letters for all protective equipment worn by the people performing the activity.

Section 5. Graphite-Based Process

The information requested below will allow us to generate an exposure assessment and risk characterization profile for each of the following baths and the associated activities involved in the operation and upkeep of the graphite-based process.

NOTE: You need to complete this section only if your facility uses a graphite-based process for making the holes conductive during the PWB manufacturing process.

5.1 Physical, Process, and Operating Conditions

Complete the table below by entering the data requested for each specific type of chemical bath listed. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH	PHYSICAL DATA			PROCESSING DATA		OPERATING CONDITIONS		
	LENGTH (inches)	WIDTH (inches)	NOMINAL VOLUME	IMMERSION ^a (seconds)	DRIP TIME ^b (seconds)	TEMP °F	AGITATION ^c	VAPOR CONTROL ^d
CLEANER/ CONDITIONER	in.	in.	gal.	sec.	sec.	°F		
GRAPHITE	in.	in.	gal.	sec.	sec.	°F		
FIXER	in.	in.	gal.	sec.	sec.	°F		
POST-CLEAN ETCH	in.	in.	gal.	sec.	sec.	°F		
ANTI-TARNISH/ ANTI-OXIDANT	in.	in.	gal.	sec.	sec.	°F		
OTHER (specify)	in.	in.	gal.	sec.	sec.	°F		

^a **Immersion Time** - Enter the average elapsed time a rack of panels is immersed in the specific process bath.

^b **Drip Time** - Enter the average elapsed time that a rack of panels is allowed to hang above the specific bath to allow chemical drainage from panels.

^c **Agitation** - Consult the key at right and enter the letter for the agitation method used in the specific chemical bath.

^d **Vapor Control** - Consult key at right and enter the letter of the vapor control method used for that specific chemical.

Agitation Methods Key

[P] - Panel agitation

[F] - Fluid circulation pump

[A] - Air sparge

[O] - Other (explain)

Vapor Control Methods Key

[P] - Push-Pull

[C] - Bath cover (when not in use)

[B] - Plastic balls (floating)

[E] - Fully enclosed

[O] - Other (explain)

AIR KNIFE/OVEN PROCESS STEP

Air pressure:	psi.
Air temperature	°F
Processing time per panel	min.
Contained unit (circle one):	Yes No

APPENDIX A

5.2 Initial Chemical Bath Make-Up Composition

Complete the chart below for each chemical component of the bath type listed. Provide the manufacturer name if the chemical used is known only by trade name. If more room is needed, please attach another sheet with the additional information. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED ^c (gallons)
CLEANER/ CONDITIONER	1.					
	2.					
	3.					
	4.					
GRAPHITE	1.					
	2.					
	3.					
	4.					
FIXER	1.					
	2.					
	3.					
	4.					
POST-CLEAN ETCH	1.					
	2.					
	3.					
	4.					
ANTI-TARNISH/ ANTI-OXIDANT	1.					
	2.					
	3.					
	4.					
OTHER (specify)	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** Enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

5.3 Chemical Bath Replacement

Complete the chart below by providing information on the process of replacing, treating, and disposing of a spent chemical bath.

BATH TYPE	CRITERIA FOR REPLACEMENT ^a	FREQUENCY ^b	DURATION OF REPLACEMENT PROCEDURE ^c	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^d	ON-SITE METHOD OF TREATMENT OR DISPOSAL ^e	ANNUAL VOLUME TREATED OR DISPOSED ^f	OFF-SITE METHOD OF TREATMENT OR DISPOSAL ^e
CLEANER/ CONDITIONER								
GRAPHITE								
FIXER								
POST-CLEAN ETCH								
ANTI-TARNISH/ ANTI-OXIDANT								
OTHER (specify)								

^a **Criteria for Replacement** - Consult the key at right and enter the letter for the criteria typically used to determine when bath replacement is necessary.

^b **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^c **Duration of Replacement** - Enter the elapsed time from the beginning of bath removal until the replacement bath is finished.

^d **Personal Protective Equip.** - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

^e **Methods of Treatment or Disposal** - Consult keys at right and enter the letter of the method used.

^f **Annual Volume Treated or Disposed** - Enter the yearly amount of the specific bath treated or disposed.

On-Site Method of Treatment or Disposal

[P] - Precipitation pretreatment on-site

[N] - PH neutralization pretreatment on-site

[S] - Disposed directly to sewer with no treatment

[D] - Drummed for off-site treatment or disposal

[R] - Recycled on-site

[O] - Other (specify)

Off-Site Method of Treatment or Disposal

[R] - Sent to recycle

[P] - Discharged to POTW

[O] - Other

Criteria for Bath Replacement

[S] - Statistical process control [T] - Time

[P] - Panel sq. ft. processed [O] - Other

[C] - Chemical testing (Specify)

Personal Protective Equipment

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory

protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

APPENDIX A

5.4 Chemical Handling Activities: Chemical Bath Replacement

Complete the table below by indicating the options your facility uses to replace each type of spent chemical bath. **If the same options are used to replace each of the various chemical baths, enter “ALL” as the type of bath and fill out only one table.** Otherwise, please photocopy and attach additional charts, as necessary.

TYPES OF BATHS ^a

REMOVAL OF SPENT BATH			CLEANING OF EQUIPMENT			NEW BATH MAKE-UP		
Method of Removing Spent Bath	Pump:		Tank Cleaning Method	Chemical flush:		Chemical Retrieval from Stock into Container	Pump:	
	Siphon:			Hand scrub:			Pour:	
	Drain/spigot:			Other (specify):			Scoop (solid):	
	Other (specify):						Other (specify):	
Remove Spent Bath	Directly to wastewater treatment:		CHEMICALS USED IN CHEMICAL FLUSH			Container Type	Open-top container:	
	Directly to sewer:						Closed-top container:	
	To open-top container:		Chemical	Gallons Per Year			Safety container:	
	To closed-top container:						Other (specify):	

^a **Types of Baths** - Enter the types of baths where the activities are used. If the chemical handling activities are the same for each bath type, enter ‘ALL.’

5.5 Chemical Bath Sampling

Provide information on the chemical bath sampling procedures used in your facility. Duration of sampling and personnel involved should include only the portion of the testing procedure involving the manual sampling of the chemical baths, not automated sampling or the testing that may occur in another part of the facility, such as the lab.

BATH TYPE	TYPE OF SAMPLING ^a	FREQUENCY ^b	DURATION OF SAMPLING ^c	NO. OF PEOPLE ^d	PROTECTIVE EQUIPMENT ^e
CLEANER/ CONDITIONER			min.		
GRAPHITE			min.		
FIXER			min.		
POST-CLEAN ETCH			min.		
ANTI-TARNISH/ ANTI-OXIDANT			min.		
OTHER (specify)			min.		

^a **Type of Sampling** - Consult the key at right and enter the type of sampling performed on the specific chemical bath.

^b **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. processed between samples. Clearly specify units (e.g., hours, square feet, etc.).

^c **Duration of Sampling** - Enter the average time for manually taking a sample from the specific chemical tank. Consider only time spent at the chemical bath..

^d **Number of People** - Enter the number of people actually involved in manually taking the chemical samples. Exclude people doing the testing but not the sampling.

^e **Personal Protective Equipment** - Consult key at right and enter the letters for all protective equipment worn by the people performing the chemical sampling.

Type of Sampling Key

[A] - Automated sampling [B] - Both
[M] - Manual sampling [N] - None

Personal Protective Equipment Key

[E] - Eye protection [G] - Gloves
[L] - Labcoat/sleeved garment [A] - Apron
[R] - Respiratory protection [B] - Boots
[Z] - All except respiratory [N] - None
protection

5.6 Chemical Handling Activities: Chemical Sampling

Complete the table below by indicating what method your facility uses to manually collect bath samples and the type of container used.

Method of Obtaining Samples	Drain/Spigot:	
	Pipette:	
	Ladle:	
	Other (specify):	
Chemical Sample Container	Open-top container:	
	Closed-top container:	

APPENDIX A

5.7 Chemical Bath Additions

Complete the following chart detailing the typical chemical additions that are made to maintain the chemical balance of each specific process baths. If more than four chemicals are added to a specific bath, attach another sheet with the additional information. If chemical additions to a bath are made automatically, do not complete the last three columns for that bath. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
CLEANER/ CONDITIONER	1.						min.		
	2.								
	3.								
	4.								
GRAPHITE	1.						min.		
	2.								
	3.								
	4.								
FIXER	1.						min.		
	2.								
	3.								
	4.								
POST-CLEAN ETCH	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath.

If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.).

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/liter, etc.) of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition Method Key

[A] - Automatic *

[M] - Manual

*** If additions are automatic [A] then do not complete the last 3 columns**

Personal Protective Equipment Key

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

5.7 Chemical Bath Additions - CONTINUED

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
ANTI-TARNISH/ ANTI-OXIDANT	1.						min.		
	2.								
	3.								
	4.								
OTHER (specify)	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.).

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/litre, etc.) Of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition**Method Key**

[A] - Automatic *

[M] - Manual

* If additions are automatic [A] then do not complete the last 3 columns

Personal Protective**Equipment Key**

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

5.8 Chemical Handling Activities: Chemical Additions

Complete the following table by indicating the methods your facility uses while performing chemical additions.

ACTIVITY	OPTIONS	
Chemical Retrieval from Stock into Container	Pump:	
	Pour:	
	Scoop (solid):	
	Other (specify):	
Container	Open-top container:	
	Closed-top container:	
	Safety container:	
	Other (specify):	
Method of Chemical Addition	Pour directly into tank:	
	Stir into tank:	
	Pour into automated chemical addition system:	
	Other (specify):	

5.9 Other Bath Related Activities

Complete the following table for any other bath related activities that your facility engages in.

BATH TYPE	TYPE OF ACTIVITY (describe)	FREQUENCY ^a	DURATION OF ACTIVITY ^b	NO. OF PEOPLE	PROTECTIVE EQUIPMENT ^c
CLEANER/ CONDITIONER					
GRAPHITE					
FIXER					
POST-CLEAN ETCH					
ANTI-TARNISH/ ANTI-OXIDANT					
OTHER (specify)					

^a **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. Processed since the last time the activity was performed. Clearly specify units (e.g., hours, square feet, etc.)

^b **Duration of Activity** - Enter the average time for performing the specified activity. Clearly specify units.

^c **Personal Protective Equipment** - Consult key on the previous page and enter the letters for all protective equipment worn by the people performing the activity.

Section 6. Carbon-Based Process

The information requested below will allow us to generate an exposure assessment and risk characterization profile for each of the following baths and the associated activities involved in the operation and upkeep of the carbon-based process.

NOTE: You need to complete this section only if your facility uses a carbon-based process for making the holes conductive during the PWB manufacturing process.

6.1 Physical, Process, and Operating Conditions

Complete the table below by entering the data requested for each specific type of chemical bath listed. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH	PHYSICAL DATA			PROCESSING DATA		OPERATING CONDITIONS		
	LENGTH (inches)	WIDTH (inches)	NOMINAL VOLUME	IMMERSION ^a (seconds)	DRIP TIME ^b (seconds)	TEMP °F	AGITATION ^c	VAPOR CONTROL ^d
CLEANER	in.	in.	gal.	sec.	sec.	°F		
CONDITIONER	in.	in.	gal.	sec.	sec.	°F		
CARBON	in.	in.	gal.	sec.	sec.	°F		
POST-CLEAN ETCH	in.	in.	gal.	sec.	sec.	°F		
ANTI-TARNISH/ ANTI-OXIDANT	in.	in.	gal.	sec.	sec.	°F		
OTHER (specify)	in.	in.	gal.	sec.	sec.	°F		

^a **Immersion Time** - Enter the average elapsed time a rack of panels is immersed in the specific process bath.

^b **Drip Time** - Enter the average elapsed time that a rack of panels is allowed to hang above the specific bath to allow chemical drainage from panels.

^c **Agitation** - Consult the key at right and enter the letter for the agitation method used in the specific chemical bath.

^d **Vapor Control** - Consult key at right and enter the letter of the vapor control method used for that specific chemical.

Agitation Methods Key

[P] - Panel Agitation

[F] - Fluid Circulation Pump

[A] - Air Sparge

[O] - Other (explain)

Vapor Control Methods Key

[P] - Push-Pull

[C] - Bath cover (when not in use)

[B] - Plastic Balls (floating)

[E] - Fully Enclosed

[O] - Other (explain)

AIR KNIFE/OVEN PROCESS STEP

Air pressure:	psi.
Air temperature	°F
Processing time per panel	min.
Contained unit (circle one):	Yes No

APPENDIX A

6.2 Initial Chemical Bath Make-Up Composition

Complete the chart below for each chemical component of the bath type listed. Provide the manufacturer name if the chemical used is known only by trade name. If more room is needed, please attach another sheet with the additional information. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED ^c (gallons)
CLEANER	1.					
	2.					
	3.					
	4.					
CONDITIONER	1.					
	2.					
	3.					
	4.					
CARBON	1.					
	2.					
	3.					
	4.					
POST-CLEAN ETCH	1.					
	2.					
	3.					
	4.					
ANTI-TARNISH/ ANTI-OXIDANT	1.					
	2.					
	3.					
	4.					
OTHER (specify)	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** Enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

6.3 Chemical Bath Replacement

Complete the chart below by providing information on the process of replacing, treating, and disposing of a spent chemical bath.

BATH TYPE	CRITERIA FOR REPLACEMENT ^a	FREQUENCY ^b	DURATION OF REPLACEMENT PROCEDURE ^c	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^d	ON-SITE METHOD OF TREATMENT OR DISPOSAL ^e	ANNUAL VOLUME TREATED OR DISPOSED ^f	OFF-SITE METHOD OF TREATMENT OR DISPOSAL ^e
CLEANER								
CONDITIONER								
CARBON								
POST-CLEAN ETCH								
ANTI-TARNISH/ ANTI-OXIDANT								
OTHER (specify)								

^a **Criteria for Replacement** - Consult the key at right and enter the letter for the criteria typically used to determine when bath replacement is necessary.

^b **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^c **Duration of Replacement** - Enter the elapsed time from the beginning of bath removal until the replacement bath is finished.

^d **Personal Protective Equip.** - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

^e **Methods of Treatment or Disposal** - Consult keys at right and enter the letter of the method used.

^f **Annual Volume Treated or Disposed** - Enter the yearly amount of the specific bath treated or disposed.

On-Site Method of Treatment or Disposal

[P] - Precipitation pretreatment on-site

[N] - PH neutralization pretreatment on-site

[S] - Disposed directly to sewer with no treatment

[D] - Drummed for off-site treatment or disposal

[R] - Recycled on-site

[O] - Other (specify)

Off-Site Method of Treatment or Disposal

[R] - Sent to recycle

[P] - Discharged to POTW

[O] - Other

Criteria for Bath Replacement

[S] - Statistical process control [T] - Time

[P] - Panel sq. ft. processed [O] - Other

[C] - Chemical testing (Specify)

Personal Protective Equipment

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory Protection

[Z] - All except respiratory

protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

APPENDIX A

6.4 Chemical Handling Activities: Chemical Bath Replacement

Complete the table below by indicating the options your facility uses to replace each type of spent chemical bath. **If the same options are used to replace each of the various chemical baths, enter “ALL” as the type of bath and fill out only one table.** Otherwise, please photocopy and attach additional charts, as necessary.

<u>TYPES OF BATHS</u> ^a

REMOVAL OF SPENT BATH			CLEANING OF EQUIPMENT			NEW BATH MAKE-UP		
Method of Removing Spent Bath	Pump:		Tank Cleaning Method	Chemical flush:		Chemical Retrieval from Stock into Container	Pump:	
	Siphon:			Hand scrub:			Pour:	
	Drain/spigot:			Other (specify):			Scoop (solid):	
	Other (specify):						Other (specify):	
Remove Spent Bath	Directly to wastewater treatment:		CHEMICALS USED IN CHEMICAL FLUSH			Container Type	Open-top container:	
	Directly to sewer:						Closed-top container:	
	To open-top container:		Chemical	Gallons Per Year	Safety container:			
	To closed-top container:				Other (specify):			

^a **Types of Baths** - Enter the types of baths where the activities are used. If the chemical handling activities are the same for each both type, enter 'ALL.'

6.5 Chemical Bath Sampling

Provide information on the chemical bath sampling procedures used in your facility. Duration of sampling and personnel involved should include only the portion of the testing procedure involving the manual sampling of the chemical baths, not automated sampling or the testing that may occur in another part of the facility, such as the lab.

BATH TYPE	TYPE OF SAMPLING ^a	FREQUENCY ^b	DURATION OF SAMPLING ^c	NO. OF PEOPLE ^d	PROTECTIVE EQUIPMENT ^e
CLEANER			min.		
CONDITIONER			min.		
CARBON			min.		
POST-CLEAN ETCH			min.		
ANTI-TARNISH/ ANTI-OXIDANT			min.		
OTHER (specify)			min.		

^a **Type of Sampling** - Consult the key at right and enter the type of sampling performed on the specific chemical bath.

^b **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. processed between samples. Clearly specify units (e.g., hours, square feet, etc.).

^c **Duration of Sampling** - Enter the average time for manually taking a sample from the specific chemical tank. Consider only time spent at the chemical bath..

^d **Number of People** - Enter the number of people actually involved in manually taking the chemical samples. Exclude people doing the testing but not the sampling.

^e **Personal Protective Equipment** - Consult key at right and enter the letters for all protective equipment worn by the people performing the chemical sampling.

Type of Sampling Key

[A] - Automated sampling [B] - Both
[M] - Manual Sampling [N] - None

Personal Protective Equipment Key

[E] - Eye protection [G] - Gloves
[L] - Labcoat/sleeved garment [A] - Apron
[R] - Respiratory protection [B] - Boots
[Z] - All except respiratory protection [N] - None protection

6.6 Chemical Handling Activities: Chemical Sampling

Complete the table below by indicating what method your facility uses to manually collect bath samples and the type of container used.

Method of Obtaining Samples	Drain/Spigot:	
	Pipette:	
	Ladle:	
	Other (specify):	
Chemical Sample Container	Open-top container:	
	Closed-top container:	

APPENDIX A

6.7 Chemical Bath Additions

Complete the following chart detailing the typical chemical additions that are made to maintain the chemical balance of each specific process baths. If more than four chemicals are added to a specific bath, attach another sheet with the additional information. If chemical additions to a bath are made automatically, do not complete the last three columns for that bath. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
CLEANER	1.						min.		
	2.								
	3.								
	4.								
CONDITIONER	1.						min.		
	2.								
	3.								
	4.								
CARBON	1.						min.		
	2.								
	3.								
	4.								
POST-CLEAN ETCH	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath.

If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.).

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/liter, etc.) of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition Method Key

[A] - Automatic *

[M] - Manual

*** If additions are automatic [A] then do not complete the last 3 columns**

Personal Protective Equipment Key

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

6.7 Chemical Bath Additions - CONTINUED

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
ANTI-TARNISH/ ANTI-OXIDANT	1.						min.		
	2.								
	3.								
	4.								
OTHER (specify)	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.).

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/litre, etc.) Of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

**Chemical Addition
Method Key**

[A] - Automatic *

[M] - Manual

*** If additions are
automatic [A] then do
not complete the last 3
columns**

**Personal Protective
Equipment Key**

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory
protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

6.8 Chemical Handling Activities: Chemical Additions

Complete the following table by indicating the methods your facility uses while performing chemical additions.

ACTIVITY	OPTIONS	
Chemical Retrieval from Stock into Container	Pump:	
	Pour:	
	Scoop (solid):	
	Other (specify):	
Container	Open-top container:	
	Closed-top container:	
	Safety container:	
	Other (specify):	
Method of Chemical Addition	Pour directly into tank:	
	Stir into tank:	
	Pour into automated chemical addition system:	
	Other (specify):	

6.9 Other Bath Related Activities

Complete the following table for any other bath related activities that your facility engages in.

BATH TYPE	TYPE OF ACTIVITY (describe)	FREQUENCY ^a	DURATION OF ACTIVITY ^b	NO. OF PEOPLE	PROTECTIVE EQUIPMENT ^c
CLEANER					
CONDITIONER					
CARBON					
POST-CLEAN ETCH					
ANTI-TARNISH/ ANTI-OXIDANT					
OTHER (specify)					

^a **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. Processed since the last time the activity was performed. Clearly specify units (e.g., hours, square feet, etc.)

^b **Duration of Activity** - Enter the average time for performing the specified activity. Clearly specify units.

^c **Personal Protective Equipment** - Consult key on the previous page and enter the letters for all protective equipment worn by the people performing the activity.

Section 7. Palladium-Based Process

The information requested below will allow us to generate an exposure assessment and risk characterization profile for each of the following baths and the associated activities involved in the operation and upkeep of the palladium-based process.

NOTE: You need to complete this section only if your facility uses a palladium-based process for making the holes conductive during the PWB manufacturing process.

7.1 Physical, Process, and Operating Conditions

Complete the table below by entering the data requested for each specific type of chemical bath listed. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH	PHYSICAL DATA			PROCESSING DATA		OPERATING CONDITIONS		
	LENGTH (inches)	WIDTH (inches)	NOMINAL VOLUME	IMMERSION ^a (seconds)	DRIP TIME ^b (seconds)	TEMP °F	AGITATION ^c	VAPOR CONTROL ^d
CLEANER/ CONDITIONER	in.	in.	gal.	sec.	sec.	°F		
PRE-DIP	in.	in.	gal.	sec.	sec.	°F		
CATALYST	in.	in.	gal.	sec.	sec.	°F		
ACCELERATOR	in.	in.	gal.	sec.	sec.	°F		
ENHANCER								
POST-CLEAN ETCH								
ANTI-TARNISH/ ANTI-OXIDANT	in.	in.	gal.	sec.	sec.	°F		
OTHER (specify)	in.	in.	gal.	sec.	sec.	°F		

^a **Immersion Time** - Enter the average elapsed time a rack of panels is immersed in the specific process bath.

^b **Drip Time** - Enter the average elapsed time that a rack of panels is allowed to hang above the specific bath to allow chemical drainage from panels.

^c **Agitation** - Consult the key at right and enter the letter for the agitation method used in the specific chemical bath.

^d **Vapor Control** - Consult key at right and enter the letter of the vapor control method used for that specific chemical.

Agitation Methods Key

[P] - Panel agitation [

[F] - Fluid circulation pump

[A] - Air sparge

[O] - Other (explain)

Vapor Control Methods Key

P] - Push-Pull

[C] - Bath cover (when not in use)

[B] - Plastic balls (floating)

[E] - Fully enclosed

[O] - Other (explain)

AIR KNIFE/OVEN PROCESS STEP

Air pressure:	psi.
Air temperature	°F
Processing time per panel	min.
Contained unit (circle one):	Yes No

APPENDIX A

7.2 Initial Chemical Bath Make-Up Composition

Complete the chart below for each chemical component of the bath type listed. Provide the manufacturer name if the chemical used is known only by trade name. If more room is needed, please attach another sheet with the additional information. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED ^c (gallons)
CLEANER/ CONDITIONER	1.					
	2.					
	3.					
	4.					
PRE-DIP	1.					
	2.					
	3.					
	4.					
PALLADIUM CATALYST	1.					
	2.					
	3.					
	4.					
ACCELERATOR	1.					
	2.					
	3.					
	4.					
ENHANCER	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** Enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

7.2 Initial Chemical Bath Make-Up Composition - CONTINUED

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	WORKING VOLUME ^a (gallons)	CONCENTRATION ^b	ANNUAL QTY. USED ^c (gallons)
POST-CLEAN ETCH	1.					
	2.					
	3.					
	4.					
ANTI-TARNISH/ ANTI-OXIDANT	1.					
	2.					
	3.					
	4.					
OTHER (specify)	1.					
	2.					
	3.					
	4.					

^a **Working Volume:** Enter the volume of the chemical used in the initial make-up of the bath. If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

^b **Concentration:** Enter the concentration of the chemical in the working volume and specify units (e.g., molarity, grams/liter, etc.) of the chemical used.

^c **Annual Quantity Used:** If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

APPENDIX A

7.3 Chemical Bath Replacement

Complete the chart below by providing information on the process of replacing, treating, and disposing of a spent chemical bath.

BATH TYPE	CRITERIA FOR REPLACEMENT ^a	FREQUENCY ^b	DURATION OF REPLACEMENT PROCEDURE ^c	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^d	ON-SITE METHOD OF TREATMENT OR DISPOSAL ^e	ANNUAL VOLUME TREATED OR DISPOSED ^f	OFF-SITE METHOD OF TREATMENT OR DISPOSAL ^e
CLEANER/ CONDITIONER								
PRE-DIP								
PALLADIUM CATALYST								
ACCELERATOR								
ENHANCER								
POST-CLEAN ETCH								
ANTI-TARNISH/ ANTI-OXIDANT								
OTHER (specify)								

^a **Criteria for Replacement** - Consult the key at right and enter the letter for the criteria typically used to determine when bath replacement is necessary.

^b **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^c **Duration of Replacement** - Enter the elapsed time from the beginning of bath removal until the replacement bath is finished.

^d **Personal Protective Equip.** - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

^e **Methods of Treatment or Disposal** - Consult keys at right and enter the letter of the method used.

^f **Annual Volume Treated or Disposed** - Enter the yearly amount of the specific bath treated or disposed.

On-Site Method of Treatment or Disposal

[P] - Precipitation pretreatment on-site

[N] - PH neutralization pretreatment on-site

[S] - Disposed directly to sewer with no treatment

[D] - Drummed for off-site treatment or disposal

[R] - Recycled on-site

[O] - Other (specify)

Off-Site Method of Treatment or Disposal

[R] - Sent to recycle

[P] - Discharged to POTW

[O] - Other

Criteria for Bath Replacement

[S] - Statistical process control

[P] - Panel sq. ft. processed

[C] - Chemical testing

[T] - Time

[O] - Other

(Specify)

Personal Protective Equipment

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory

protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

7.4 Chemical Handling Activities: Chemical Bath Replacement

Complete the table below by indicating the options your facility uses to replace each type of spent chemical bath. **If the same options are used to replace each of the various chemical baths, enter “ALL” as the type of bath and fill out only one table.** Otherwise, please photocopy and attach additional charts, as necessary.

<u>TYPES OF BATHS</u> ^a

REMOVAL OF SPENT BATH			CLEANING OF EQUIPMENT			NEW BATH MAKE-UP		
Method of Removing Spent Bath	Pump:		Tank Cleaning Method	Chemical flush:		Chemical Retrieval from Stock into Container	Pump:	
	Siphon:			Hand scrub:			Pour:	
	Drain/spigot:			Other (specify):			Scoop (solid):	
	Other (specify):						Other (specify):	
Remove Spent Bath	Directly to wastewater treatment:		CHEMICALS USED IN CHEMICAL FLUSH			Container Type	Open-top container:	
	Directly to sewer:							
	To open-top container:		Chemical	Gallons Per Year	Safety container:			
	To closed-top container:				Other (specify):			

^a **Types of Baths** - Enter the types of baths where the activities are used. If the chemical handling activities are the same for each both type, enter 'ALL.'

7.5 Chemical Bath Sampling

Provide information on the chemical bath sampling procedures used in your facility. Duration of sampling and personnel involved should include only the portion of the testing procedure involving the manual sampling of the chemical baths, not automated sampling or the testing that may occur in another part of the facility, such as the lab.

BATH TYPE	TYPE OF SAMPLING ^a	FREQUENCY ^b	DURATION OF SAMPLING ^c	NO. OF PEOPLE ^d	PROTECTIVE EQUIPMENT ^e
CLEANER/ CONDITIONER			min.		
PRE-DIP			min.		
PALLADIUM CATALYST			min.		
ACCELERATOR			min.		
ENHANCER			min.		
POST-CLEAN ETCH			min.		
ANTI-TARNISH/ ANTI-OXIDANT			min.		
OTHER (specify)			min.		

^a **Type of Sampling** - Consult the key at right and enter the type of sampling performed on the specific chemical bath.

^b **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. processed between samples. Clearly specify units (e.g., hours, square feet, etc.).

^c **Duration of Sampling** - Enter the average time for manually taking a sample from the specific chemical tank. Consider only time spent at the chemical bath..

^d **Number of People** - Enter the number of people actually involved in manually taking the chemical samples. Exclude people doing the testing but not the sampling.

^e **Personal Protective Equipment** - Consult key at right and enter the letters for all protective equipment worn by the people performing the chemical sampling.

Type of Sampling Key

[A] - Automated sampling [B] - Both
[M] - Manual sampling [N] - None

Personal Protective Equipment Key

[E] - Eye protection [G] - Gloves
[L] - Labcoat/sleeved garment [A] - Apron
[R] - Respiratory protection [B] - Boots
[Z] - All except respiratory [N] - None
protection

7.6 Chemical Handling Activities: Chemical Sampling

Complete the table below by indicating what method your facility uses to manually collect bath samples and the type of container used.

Method of Obtaining Samples	Drain/Spigot:	
	Pipette:	
	Ladle:	
	Other (specify):	
Chemical Sample Container	Open-top container:	
	Closed-top container:	

7.7 Chemical Bath Additions

Complete the following chart detailing the typical chemical additions that are made to maintain the chemical balance of each specific process baths. If more than four chemicals are added to a specific bath, attach another sheet with the additional information. If chemical additions to a bath are made automatically, do not complete the last three columns for that bath. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
CLEANER/ CONDITIONER	1.						min.		
	2.								
	3.								
	4.								
PRE-DIP	1.						min.		
	2.								
	3.								
	4.								
PALLADIUM CATALYST	1.						min.		
	2.								
	3.								
	4.								
ACCELERATOR	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath.

If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.)

^b **Concentration** - Enter the concentration (e.g., molarity, volume %, grams/liter, etc.) of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.)

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition Method Key

[A] - Automatic *
[M] - Manual

* If additions are automatic [A] then do not complete the last 3 columns

Personal Protective Equipment Key

[E] - Eye protection
[L] - Labcoat/sleeved garment
[R] - Respiratory protection
[Z] - All except respiratory protection
[G] - Gloves
[A] - Apron
[B] - Boots
[N] - None

APPENDIX A

7.7 Chemical Bath Additions - CONTINUED

BATH TYPE		CHEMICAL ADDED	AVERAGE VOLUME ADDED ^a	CONCENTRATION ^b	FREQUENCY ^c	CHEMICAL ADDITION METHOD ^d	DURATION OF ADDITION ^e (minutes)	NO. OF PEOPLE	PERSONAL PROTECTIVE EQUIPMENT ^f
ENHANCER									
POST-CLEAN ETCH									
ANTI-TARNISH/ ANTI-OXIDANT	1.						min.		
	2.								
	3.								
	4.								
OTHER (specify)	1.						min.		
	2.								
	3.								
	4.								

^a **Average Volume Added** - Enter the average volume in gallons of each chemical added to maintain the specific bath.

If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weights in pounds and clearly specify the units (lbs.)

^b **Concentration** - enter the concentration (e.g., molarity, volume %, grams/litre, etc.) Of the chemical in the volume being added.

^c **Frequency** - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^d **Duration of Addition Method** - Consult key at right and enter the appropriate letter for the method used for that specific bath.

^e **Duration of Addition** - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f **Personal Protective Equipment** - Consult key at right and enter the letters for all of the protective equipment worn by the people physically making the addition.

Chemical Addition

Method Key

[A] - Automatic *

[M] - Manual

*** If additions are automatic [A] then do not complete the last 3 columns**

Personal Protective

Equipment Key

[E] - Eye protection

[L] - Labcoat/sleeved garment

[R] - Respiratory protection

[Z] - All except respiratory protection

[G] - Gloves

[A] - Apron

[B] - Boots

[N] - None

7.8 Chemical Handling Activities: Chemical Additions

Complete the following table by indicating the methods your facility uses while performing chemical additions.

ACTIVITY	OPTIONS	
Chemical Retrieval from Stock into Container	Pump:	
	Pour:	
	Scoop (solid):	
	Other (specify):	
Container	Open-top container:	
	Closed-top container:	
	Safety container:	
	Other (specify):	
Method of Chemical Addition	Pour directly into tank:	
	Stir into tank:	
	Pour into automated chemical addition system:	
	Other (specify):	

7.9 Other Bath Related Activities

Complete the following table for any other bath related activities that your facility engages in.

BATH TYPE	TYPE OF ACTIVITY (describe)	FREQUENCY ^a	DURATION OF ACTIVITY ^b	NO. OF PEOPLE	PROTECTIVE EQUIPMENT ^c
CLEANER/ CONDITIONER					
PRE-DIP					
PALLADIUM CATALYST					
ACCELERATOR					
ENHANCER					
POST-CLEAN ETCH					
ANTI-TARNISH/ ANTI-OXIDANT					
OTHER (specify)					

^a **Frequency** - Enter the average amount of time elapsed or number of panel sq. ft. Processed since the last time the activity was performed. Clearly specify units (e.g., hours, square feet, etc.)

^b **Duration of Activity** - Enter the average time for performing the specified activity. Clearly specify units.

^c **Personal Protective Equipment** - Consult key on the previous page and enter the letters for all protective equipment worn by the people performing the activity.

Definitions and Abbreviations

Direct discharge	Wastewater discharge directly to a stream or river
Indirect discharge	Wastewater discharge to a publicly owned treatment works (POTW)
Zero discharge	No industrial wasteater discharge
Cu	copper
cu.ft.	cubic feet
DfE	Design for the Environment
EPA	U.S. Environmental Protection Agency
F	fahrenheit
ft.	feet
gal.	gallons
gal./day	gallons per day
gpm	gallons per minute
hrs.	hours
lbs.	pounds
MHC	making holes conductive
min.	minutes
mg/l	milligrams per liter
OEM	original equipment manufacturer
Pd	palladium
PWB	printed wiring board
sec.	seconds
sq.ft.	square feet
sq.in.	square inch
Sn	tin
TDS	total dissolved solids
TSS	total suspended solids
TTO	total toxic organics
yr.	year

A.2 Observer Data Sheet

Observer Data Sheet

DfE PWB Performance Demonstrations

Facility name and location: _____

MHC Process type: _____ Installation Date: _____

Date: _____ Contact name: _____

Test Panel Run		
Make and Model of rack or panel transport system:		
Overall MHC process line dimensions		
Length (ft.):	Width (ft.):	Height (ft.):
Temperature of the process room:		
Desmear type (permanganate or plasma):		
Average number of panels per rack:	Average space between panels in rack:	
Average size of panel in rack: Length (in.):	Width (in.):	
At what % of capacity is the line currently running?	At what % of capacity is the line typically running?	
Open the panel bags. Were the bags still sealed the day of the demonstration? If no, when was the bag opened and where/how were the panels stored?		
Place the panels in the system. For rack systems, note the rack configuration (diagram the rack configuration and note the locations of the 3 test panels):		
While running the test panels, verify each process step and complete the table on the next page.		
Overall System Timing: from system start (after loading racks) to system stop (before unloading racks); <i>[Do not include desmear time]</i> :		
After processing the panels through the MHC line, flash plate with 0.1 mil copper. Record the current used and time used:		
Current = _____ A		Time = _____ sec.

APPENDIX A

Test Panel Run					
Test Board Serial Numbers: 1. _____ 2. _____ 3. _____					
Bath Name (from schematic)	Tank or Station #	Equipment ^a	Bath Temp	Immersion Time	Drip Time
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

^a List number, type of:

Agitation:	Vapor Control:	Filter Type:	Heater Control:	Water Rinses:
[PA] - Panel Agitation	[PP] - Push/Pull	[BF] - Bag	[TH] - Thermostat	[CN] - Continuous
[CP] - Circulation Pump	[BC] - Bath Cover	[CF] - Cartridge	[TM] - Timer	[DP] - Continuous During Process
[AS] - Air Sparge	[FB] - Floating Balls	[OF] - Other	[PR] - Programmed	[PP] - Partial During Process
[OA] - Other (describe)	[FE] - Fully Enclosed	[OH] - Other (describe)	[OW] - Other (describe)	
	[OV] - Other (describe)			

Verification of Part A (mark any changes on working copy of Part A):**Throughput:**

Verify the overall throughput (Part A, Q1.1) is recorded as **surface square feet** and that it is equal to the per shift throughput (Part A, Q1.4): **G**

Ventilation:

Verify the type of ventilation as recorded in Part A, Question 2.1: **Q**

Wastewater characterization:

Review discharge and sludge data recorded in Part A, Question 2.3 with wastewater treatment plant operator. Did the data recorded refer to plant-wide data or MHC process line-specific data?

Verify the estimate of the percentage of waste treatment due to MHC process: **Q**

Tank volumes:

Verify the length, width, and nominal volume of each tank, as recorded in Part A: **Q**

Water Use:

Verify Part A, Question 3.2, for each tank:

Flow Controls verified	Q
Daily water flow rate verified	Q
Cascade process steps verified	Q

Have you implemented any other water conservation measures on the MHC line?

If yes, describe:

Is water consumption dependent upon capacity of the line?

Pollution Prevention:

Have you used any other pollution prevention techniques on the MHC line? (e.g., covered tanks to reduce evaporation, measures to reduce dragout, changes to conserve water, etc.)

If yes, describe and quantify results (note: if results have not been quantify, please provide an estimate):

If your throughput changed during the time new pollution prevention techniques were implemented, estimate how much (if any) of the pollution prevention reductions are due the throughput changes:

Equipment Maintenance	
Estimate the maintenance requirements (excluding filter changes and bath changes) of the MHC process equipment for both outside service calls (maintenance by vendor or service company) and in-house maintenance (by facility personnel).	
Describe the typical maintenance activities associated with the MHC process line (e.g., vibration rack repairs, motor repair/replacement, conveyor repairs, valve leaks, etc.):	
OUTSIDE SERVICE CALLS	
Average time spent per week:	
Average cost:	
Average downtime:	
Do you call service for a recurring problem? If yes, describe:	
IN-HOUSE MAINTENANCE	
Average time spent per week:	
Average downtime:	
Is there a recurring maintenance problem? If yes, describe:	

Rack or Conveyor Cleaning	
Is rack or conveyor cleaned continuously during the process?	
Frequency of rack or conveyor cleaning:	
Number of personnel involved:	
Personal protective equipment (see key):	
Rack Cleaning Method (see key): OR	
Conveyor Cleaning Method (see key):	
Average time required to clean:	
Cleaning chemical used:	
Cleaning schedule (after hours, during hours in MHC room, or during hours outside MHC room)	

Personal Protective Equipment Key:

[E]-Eye Protection	[G]-Gloves
[L]-Labcoat/Sleeved garment	[A]-Apron
[R]-Respiratory Protection	[B]-Boots
[Z]-All except Respiratory Protection	[N]-None

Rack Cleaning Method:

[C]-Chemical bath on MHC process line
 [D]-Chemical bath on another line
 [T]-Temporary chemical bath
 [S]-Manual scrubbing with chemical
 [M]-non-chemical cleaning
 [N]-None

Conveyor Cleaning Method:

[C]-Chemical rinsing or soaking
 [S]-Manual scrubbing with chemical
 [M]-Non-chemical cleaning
 [N]-None

Chemical Bath Sampling						
Bath Type	Type of Sampling ^a	Frequency ^b	Duration of Sampling ^c	Protective Equipment ^d	Method of Sampling ^e	Sample Container ^f
Cleaner/Conditioner						
Micro Etch						
Activator/Catalyst						
Accelerator						
Electroless Copper						
Reducer/Neutralizer						
Anti-tarnish/Anti-oxidant						
Other (specify)						
Other (specify)						

a Type of Sampling
 [A]-Automated
 [M]-Manual
 [N]-None

b Frequency: Enter the average time elapsed or number of panel sq. ft. processed between samples. Clearly specify units (e.g., hours, sq. ft., etc.)

c Duration of Sampling: Enter the average time for manually taking a sample from the tank.

d Protective Equipment: Consult the key for the above table and enter the letters for all protective equipment worn by the person performing the chemical sampling.

e Method of Obtaining Samples:
 [D]-Drain or spigot
 [P]-Pipette
 [L]-Ladle
 [O]-Other (specify)

f Chemical Sample Container
 [O]-Open-top container
 [C]-Closed-top container

APPENDIX A

Energy Usage					
For each piece of equipment in the MHC line using energy, complete the table below:					
Equipment Type, Make, Model	Tank or Station # ^a	Power Rating (from nameplate)	Load (% capacity in use)	Period of Usage	Machine Control
				<input type="checkbox"/> continuous <input type="checkbox"/> continuous during process cycle <input type="checkbox"/> partial during process cycle. If partial, record how often: <input type="checkbox"/> other:	<input type="checkbox"/> timer <input type="checkbox"/> program <input type="checkbox"/> operator/manual <input type="checkbox"/> other:
				<input type="checkbox"/> continuous <input type="checkbox"/> continuous during process cycle <input type="checkbox"/> partial during process cycle. If partial, record how often: <input type="checkbox"/> other:	<input type="checkbox"/> timer <input type="checkbox"/> program <input type="checkbox"/> operator/manual <input type="checkbox"/> other:
				<input type="checkbox"/> continuous <input type="checkbox"/> continuous during process cycle <input type="checkbox"/> partial during process cycle. If partial, record how often: <input type="checkbox"/> other:	<input type="checkbox"/> timer <input type="checkbox"/> program <input type="checkbox"/> operator/manual <input type="checkbox"/> other:
				<input type="checkbox"/> continuous <input type="checkbox"/> continuous during process cycle <input type="checkbox"/> partial during process cycle. If partial, record how often: <input type="checkbox"/> other:	<input type="checkbox"/> timer <input type="checkbox"/> program <input type="checkbox"/> operator/manual <input type="checkbox"/> other:
				<input type="checkbox"/> continuous <input type="checkbox"/> continuous during process cycle <input type="checkbox"/> partial during process cycle. If partial, record how often: <input type="checkbox"/> other:	<input type="checkbox"/> timer <input type="checkbox"/> program <input type="checkbox"/> operator/manual <input type="checkbox"/> other:

^a Specify whether tank number or process flow diagram step numbers are used.

Comparative Evaluation

If the facility has switched from a previous system to the current system, complete this page.

Process History:

In Part A, Question 3.4, the facility recorded their reason(s) for changing to their current system.

Have they realized this benefit to a greater or lesser extent than expected? Explain and obtain (attach) quantitative information if not given in Part A.

Were any changes made when the line was installed that were not part of the system or were optional (e.g., flow control valves added to water rinses? cascaded water rinses? etc.)? Explain:

Product Quality:

What, if any, changes were noticed in the quality of the boards produced?

Ease of Use:

Does the current process require more or less effort than the previous process and why (e.g., chemical bath replacement, process steps or activities created or eliminated, such as rack loading, etc.)?

Does this process require more "fine tuning" than the previous process? (e.g., can it handle a range of operating concentrations, such as bath temperature variations? does it need more frequent chemical additions or monitoring? etc.). Explain:

Installation:

How long was the debug period when this system was installed?

What were the types of problems encountered?

How does this compare with the previous system installation?

Manufacturing Process Changes: How did you change your upstream or downstream processes when this system was installed? (e.g., did you change your desmear? did you have to make changes in your electrolytic line?)

Personnel: Do you need the same number of operators to operate the current line as your previous line? [Verify that any changes were not caused by a change in throughput].

Waste Treatment:

Have any of your waste treatment methods or volumes changed due to the installation of this system (not associated with volume changes due to throughput changes)?

If yes, describe the change(s) and attach quantitative information, if available:

Process Safety:

Have any additional OSHA-related procedures or issues arisen as a result of changing to the present system (e.g., machinery lock-outs while cleaning, etc.)? If so, describe:

International Sites

For international sites only, do any bans or phase-outs of chemicals affect your choice of chemicals or technologies used in the MHC process? (e.g., Quadrol or EDTA ban)

For international sites only, what is the regulatory atmosphere in the country and what effects does it have on the MHC process? Are applicable regulations local, regional, or national?

A.3 Facility Background Information Sheet

Design for the Environment

Printed Wiring Board Project Performance Demonstrations Questionnaire

Please complete this questionnaire, make a copy for your records, and send the original to:

**Cheryl Keenan
Abt Associates
55 Wheeler Street
Cambridge, MA 02138**

NOTE: The completed questionnaire must be returned PRIOR TO the scheduled site visit.

FACILITY AND CONTACT INFORMATION

Facility Identification

Company Name:					
Site Name:					
Street Address:					
City:		State:		Zip:	

Contact Identification

Enter the names of the persons who can be contacted regarding this survey.

Name:		
Title		
Phone:		
Fax:		
E-Mail:		

Section 1. Facility Characterization

Estimate manufacturing data for the previous 12 month period or other convenient time period of 12 consecutive months (e.g., FY94). Only consider the portion of the facility dedicated to PWB manufacturing when entering employee and facility size data.

1.1 General Information			
Size of portion of facility used for manufacturing PWBs:	sq. ft.	Number of days MHC line is in operation:	days/yr
Number of full-time equivalent employees (FTEs):		Total PWB panel sq. footage processed by the MHC process:	surface sq.ft/yr
Number of employee work days per year:	days/yr		

1.2 Facility Type

Type of PWB manufacturing facility (check one)	Independent		OEM	
--	-------------	--	-----	--

1.3 Process Type

Estimate the percentage of PWBs manufactured at your facility using the following methods for making holes conductive (MHC). Specify "other" entry.

Type of PWB Process	Percent of Total	Type of PWB Process	Percent of Total
Standard electroless copper	%	Conductive polymer	%
Palladium-based system	%	Conductive inks	\$
Carbon-based system	%	Other:	%
Graphite-based system	%	Other:	%
Non-formaldehyde electroless	%	TOTAL	100 %

1.4 General Process Line Data

Process Data	Shift			
	1	2	3	4
Number of hours per shift:				
Number of hours the MHC line is in operation per shift:				
Average surface square feet of PWB panel processed by the MHC line per shift.				

1.5 Process Area Employees

Complete the following table by indicating the number of employees of each type that perform work duties in the same process room as the MHC line for each shift and for what length of time. Report the number of hours per employee. Consider only workers who have regularly scheduled responsibilities physically within the process room. Specify “other” entry. Enter “N/A” in any category not applicable.

Type of Process Area Worker	Number of Employees per Shift				Hours per Shift per Employee in Process Area (first shift)
	Shift 1	Shift 2	Shift 3	Shift 4	
Line Operators					Hrs.
Lab Technicians					Hrs.
Maintenance Workers					Hrs.
Wastewater Treatment Operators					Hrs.
Supervisory Personnel					Hrs.
Other:					Hrs.
Other:					Hrs.
EXAMPLE	3	2	2		8 Hrs.

Section 2. General Process Data

The information in this section will be used to identify the physical parameters of the process equipment as well as any operating conditions common to the entire process line.

2.1 Process Parameters

Size of the room containing the process:	sq. ft.		
Is the process area ventilated (circle one)?	Yes	No	
Air flow rate:	cu. ft./min.		
Type of ventilation? (Check one)	General	Local	
Amount of water used by the MHC process line when operating:	gal./day		

2.2 Wastewater Characterization

Estimate the average and maximum values for the wastewater from the making holes conductive line before treatment. Enter "ND" for not detectable.

	AVERAGE	MAXIMUM
Flow	gpm	gpm
TDA	mg/l	mg/l
Ph		
Cu	mg/l	mg/l

	AVERAGE	MAXIMUM
Pd	mg/l	mt/l
Sn	mg/l	mg/l
TSS	mg/l	mg/l
TTO	mg/l	mg/l

2.3 Wastewater Discharge and Sludge Data

Wastewater discharge type: (check one)	Direct	Indirect	Zero
Annual weight (pounds) of sludge generated:			
Duration of treatment (e.g., length of time for a gallon to be treated):			
Number of employees in waste treatment:			
Hazardous chemical disposal costs (annual):			
Percent solids of sludge:			
Percentage of total quantity generated by the MHC process:			
Method of sludge recycle/disposal:	[R] - Metals Reclaimed [D] - Stabilized and Landfilled [O] - Other (specify)		
Waste treatment chemicals used for treatment of MHC process line wastewater:			
Type (Chemical Name)	Quantity (gal./yr.)		

Section 3. Process Description

3.1 Process Schematic

Fill in the table below by identifying what type of making holes conductive process (e.g., electroless copper) your facility uses. Then, using the proper key at the bottom of the page, identify which letter corresponds with the first step in your process and write that letter in the first box (see example). Continue using the key to fill in boxes for each step in your process until your entire making holes conductive process is represented. If your process is not represented by a key below, complete the chart by writing in the name of each process step in your particular making holes conductive line. Finally, consult the process automation key at bottom right and enter the appropriate type of automation for the MHC process line. If the process is partially automated, enter the appropriate process automation letter for each step in the upper right-hand corner box (see example).

Type of Process (write in process name)	Process Automation Letter (see key below right)		Process Steps of Your Facility (begin here)															
	Process Step Letter (see key below)	Ex.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
		A																

ELECTROLESS COPPER PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	GRAPHITE-BASED PROCESS STEPS	PROCESS AUTOMATION
[A] - Cleaner/Cleaner	[A] - Cleaner/Conditioner	[A] - Cleaner/Conditioner	[A] - Cleaner/Conditioner	TYPE OF PROCESS AUTOMATION FOR ENTIRE MHC PROCESS (Consult the key below) * If the MHC process is partially automated (option R) enter 'R' on above line. Then, for each process step in chart above, consult the key below and enter the appropriate process automation letter in the box located in the upper right-hand corner of each process step (see example).
[B] - Micro Etch	[B] - Graphite	[B] - Graphite	[B] - Graphite	
[C] - Pre-dip	[C] - Fixer	[C] - Fixer	[C] - Fixer	
[D] - Activator/Catalyst	[D] - Air Knife/Oven	[D] - Air Knife/Oven	[D] - Air Knife/Oven	
[E] - Accelerator	[E] - Post-clean Etch	[E] - Post-clean Etch	[E] - Post-clean Etch	
[F] - Electroless Copper	[F] - Anti-tarnish/ Anti-oxidant	[F] - Anti-tarnish/ Anti-oxidant	[F] - Anti-tarnish/ Anti-oxidant	
[G] - Reducer/Neutralizer	[W] - Water rinse	[W] - Water rinse	[W] - Water rinse	
[H] - Anti-tarnish / Anti-oxidant	[O] - Other (specify step)	[O] - Other (specify step)	[O] - Other (specify step)	
[W] - Water rinse				
[O] - Other (specify step)				

Process Automation Key	
[P] - Automated non-conveyORIZED	[S] - Manually controlled hoist
[Q] - Automated conveyORIZED	[T] - Manual (no automation)
[R] - Partially automated *	[V] - Other (specify)

APPENDIX A

3.2 Rinse Bath Water Usage

Consult the process schematic in Section 3.1 to obtain the process step numbers associated with each of the water rinse baths present. Enter, in the table below, the process step number along with the flow control and flow rate data requested for each water rinse bath. If the water rinse bath is part of a cascade, you need only report the daily water flow rate of one bath in the cascade.

Process Step Number ^a	Flow Control ^b	Daily Water Flow Rate ^c	Cascade Water Process Steps ^d
Example: 8	R	2,400 gal./day	8 - 6
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	
		gal./day	

^a Process Step Number - Consult the process schematic in question 3.1 and enter the process step number of the specific water rinse tank.

^b Flow Control - Consult key at right and enter the letter for the flow control method used for that specific rinse bath.

^c Daily Water Flow Rate - Enter the average daily flow rate for the specific water rinse tank.

^d Cascade Water Process Steps - Enter the process step number for each water rinse tank in cascade with the present tank.

Flow Control Methods Key

[C] - Conductivity Meter

[P] - pH Meter

[V] - Operator control valve

[R] - Flow Restrictor

[N] - None (continuous flow)

[O] - Other (explain)

3.3 Rack or Conveyor Cleaning

Complete the following table for your rack cleaning chemicals (for non-conveyorized MHC processes) or for conveyor cleaning equipment.

Are chemicals listed below used in rack cleaning or conveyor cleaning?		Rack		Conveyor	
Chemical	Grade	Quantity used per year			
		gal.			
		gal.			
		gal.			

3.4 Process History (complete only if you have changed from one system to another)

Complete the table below by indicating what making holes conductive process (es) your facility has employed in the past. In the second table, indicate the reasons for the process change and estimate or quantify, if possible, how the change has had an effect upon production.

FORMER MAKING HOLES CONDUCTIVE PROCESS	DATE OF CHANGE TO CURRENT PROCESS
ELECTROLESS COPPER	
PALLADIUM-BASED	
GRAPHITE-BASED	
CARBON-BASED	
COPPER SEED	
ELECTROLESS NICKEL	
OTHER (specify)	

REASONS FOR CHANGE AND RESULTS			
Reason (check all that apply)		Prior to this System ^a	Present System
	Water Consumption	gal/day	gal/day
	Process Cycle-Time	min/cycle	min/cycle
	Cost	\$/ft ²	\$/ft ²
	Worker Exposure (provide monitoring data if available)		
	Performance (provide data on changes in rejection rate, number of cycles before failure, etc.)		
	Customer Acceptance		
	Product Quality		
	Process Maintenance		
	Other:		
	Other:		
	Other:		

^a If no quantitative information is available, enter [B] - Better, [W] - Worse, [N] - No change.

Section 4. Palladium-Based Process

The information requested below will allow us to generate an exposure assessment and risk characterization profile for each of the following baths and the associated activities involved in the operation and upkeep of the palladium-based process.

4.1 Physical, Process, and Operating Conditions

Complete the table below by entering the data requested for each specific type of chemical bath listed. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH	LENGTH (inches)	WIDTH (inches)	NOMINAL VOLUME
CLEANER/ CONDITIONER	in.	in.	gal.
PRE-DIP	in.	in.	gal.
ACCELERATOR	in.	in.	gal.
ENHANCER	in.	in.	gal.
POST-CLEAN ETCH	in.	in.	gal.
ANTI-TARNISH/ ANTI-OXIDANT	in.	in.	gal.
OTHER (specify)	in.	in.	gal.
	in.	in.	gal.
	in.	in.	gal.
	in.	in.	gal.

4.2 Initial Chemical Bath Make-Up Composition

Complete the chart below for each chemical component of the bath type listed. Provide the manufacturer name if the chemical used is known only by trade name. If more room is needed, please attach another sheet with the additional information. If two tanks of the same type are used within the process, list the data for a single tank only.

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	ANNUAL QTY. USED ^a (gallons)
CLEANER/ CONDITIONER	1.			
	2.			
	3.			
	4.			
PRE-DIP	1.			
	2.			
	3.			
	4.			
PALLADIUM CATALYST	1.			
	2.			
	3.			
	4.			
ACCELERATOR	1.			
	2.			
	3.			
	4.			
ENHANCER	1.			
	2.			
	3.			
	4.			

^a Annual Quantity Used - If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs.).

APPENDIX A

4.2 Initial Chemical Bath Make-Up Composition - CONTINUED

BATH		CHEMICAL NAME	MANUFACTURER (if applicable)	ANNUAL QTY. USED ^a (gallons)
POST-CLEAN ETCH	1.			
	2.			
	3.			
	4.			
ANTI-TARNISH/ ANTI-OXIDANT	1.			
	2.			
	3.			
	4.			
OTHER (specify)	1.			
	2.			
	3.			
	4.			

^a Annual Quantity Used - If the amount of a particular chemical used is measured by weight (i.e., crystalline chemicals) instead of volume, enter the weight in pounds and clearly specify the units (lbs).

4.3 Chemical Bath Replacement

Complete the chart below by providing information on the process of replacing, treating, and disposing of a spent chemical bath.

Bath Type	Criteria for Replacement ^a	Frequency ^b	Tank Cleaning Method ^c	Duration of Replacement Procedure ^d	Personal Protective Equipment ^e	Chemicals Used in Tank Flush ^f		Method of Treatment or Disposal ^g	Annual Volume Treated or Disposed ^h	New Bath Make-Up Method ⁱ
Cleaner/Conditioner						Name:	gal/yr.			
Pre-Dip						Name:	gal/yr.			
Palladium Catalyst						Name:	gal/yr.			
Accelerator						Name:	gal/yr.			
Enhancer						Name:	gal/yr.			
Post-Clean Etch						Name:	gal/yr.			
Anti-Tarnish/Anti-Oxidant						Name:	gal/yr.			
Other (specify)						Name:	gal/yr.			

^a Criteria for Replacement - Consult the key at right and enter the letter for the criteria typically used to determine when bath replacement is necessary.

^b Frequency - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^c Tank Cleaning Method - Consult the key at right and enter the letters for the method typically used to clean the tanks.

^d Duration of Replacement - Enter the elapsed time from the beginning of bath removal until the replacement bath is finished.

^e Personal Protective Equip. - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

^f Chemicals Used in Tank Flush - enter the name of any chemicals used to clean the tanks (including water) and estimate the yearly amounts used.

^g Methods of Treat. or Disp. - Consult keys at right and enter the letter of the method used.

^h Annual Voll. Treat. or Disp. - Enter th yearly amount of the specific bath treated or disposed.

ⁱ New Bath Make-Up Method - Consult the key at right and enter the letter for the method used to fill the tanks with new bath.

Personal Protective Equipment

[E] - Eye protection [G] - Gloves
 [L] - Labcoat/Sleeved garment [A] - Apron
 [R] - Respiratory protection [B] - Boots
 [Z] - All except respiratory [N] - None protection

Tank Cleaning Method

[C] - Chemical Flush [H] - Hand Scrub
 [W] - Water Rinse [O] - Other (specify)

Criteria for Bath Replacement

[S] - Statistical process control [T] - Time
 [P] - Panel sq. ft. processed [O] - Other (specify)
 [C] - Chemical testing

Method of Treatment or Disposal

[P] - Precipitation pretreatment on-site
 [N] - pH neutralization pretreatment on-site
 [S] - Disposed directly to sewer with no treatment
 [D] - Drummed for off-site treatment or disposal
 [RN] - Recycled on-site
 [RF] - Recycled off-site
 [O] - Other (specify)

New Bath Make-Up Method

[PA] - Pumped automatically
 [PM] - Pumped manually
 [R] - Poured
 [S] - Scooped (solid)
 [O] - Other (specify)

APPENDIX A

4.4 Chemical Bath Additions

Complete the following chart detailing the typical chemical additions that are made to maintain the chemical balance of each specific process baths. If more than four chemicals are added to a specific bath, attach another sheet with the additional information. If chemical additions to a bath are made automatically, do not complete the last three columns for that bath. If two tanks of the same type are used within the process, list the data for a single tank only.

Bath Type	Chemical Added	Frequency ^a	Method of Chemical Retrieval From Stock ^b	Chemical Container Type ^c	Method of Chemical Addition to Tank ^d	Duration of Addition ^e (minutes)	Personal Protective Equipment ^f
CLEANER/ CONDITIONER	1.						
	2.						
	3.						
	4.						
PRE-DIP	1.						
	2.						
	3.						
	4.						
PALLADIUM CATALYST	1.						
	2.						
	3.						
	4.						
ACCELERATOR	1.						
	2.						
	3.						
	4.						

^a Frequency - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Cleanly specify units (e.g., hours, sq. ft., etc.).

^b Method of Chemical Retrieval from Stock - Consult the key at right and enter the letter for the method used to obtain chemicals from the stock for addition to the tanks.

^c Chemical Container Type - Consult the key at right and enter the letters for the type of container used to transfer chemicals from stock to the tanks.

^d Method of Chemical Addition to Tank - Consult the key at right and enter the letters for the method typically used to add chemicals to the tanks.

^e Duration of Addition - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f Personal Protective Equipment - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

Method Chemical Retrieval Key

[P] - Pumped
[PR] - Poured
[S] - Scooped
[O] - Other

Container Type

[OT] - Open-top
[CT] - Closed-top
[SC] - Safety container
[O] - Other (specify)

Method of Chemical Addition Key

[A] - Automatic ^a
[P] - Pumped manually
[PR] - Poured
[S] - Scooped
[O] - Other (specify)

*** If additions are automatic [A] then do not complete the last two columns.**

Personal Protective Equipment Key

[E] - Eye protection
[L] - Labcoat/Sleeved garment protection
[B] - Boots
[Z] - All except respiratory
[G] - Gloves
[A] - Apron
[R] - Respiratory protection
[N] - None

4.4 Chemical Bath Additions - CONTINUED

Bath Type		Chemical Added	Frequency ^a	Method of Chemical Retrieval From Stock ^b	Chemical Container Type ^c	Method of Chemical Addition to Tank ^d	Duration of Addition ^e (minutes)	Personal Protective Equipment ^f
CLEANER/ CONDITIONER	1.							
	2.							
	3.							
	4.							
PRE-DIP	1.							
	2.							
	3.							
	4.							
PALLADIUM CATALYST	1.							
	2.							
	3.							
	4.							
ACCELERATOR	1.							
	2.							
	3.							
	4.							

^a Frequency - Enter the average amount of time elapsed or number of square feet processed between bath replacements. Clearly specify units (e.g., hours, sq. ft., etc.).

^b Method of Chemical Retrieval from Stock - Consult the key at right and enter the letter for the method used to obtain chemicals from the stock for addition to the tanks.

^c Chemical Container Type - Consult the key at right and enter the letters for the type of container used to transfer chemicals from stock to the tanks.

^d Method of Chemical Addition to Tank - Consult the key at right and enter the letters for the method typically used to add chemicals to the tanks.

^e Duration of Addition - Enter the average elapsed time from the retrieval of the chemical stock through the completion of the addition of all chemicals.

^f Personal Protective Equipment - Consult key at right and enter the letters of all the protective equipment worn by the workers physically replacing the spent bath.

**Method Chemical
Retrieval Key**

[P] - Pumped
[PR] - Poured
[S] - Scooped
[O] - Other

Container Type

[OT] - Open-top
[CT] - Closed-top
[SC] - Safety container
[O] - Other (specify)

Method of Chemical Addition Key

[A] - Automatic ^a
[P] - Pumped Manually
[PR] - Poured
[S] - Scooped
[O] - Other (specify)

*** If additions are automatic [A] then
do not complete the last two columns.**

**Personal Protective Equipment
Key**

[E] - Eye protection
[L] - Labcoat/Sleeved garment
protection
[B] - Boots
[Z] - All except respiratory
[G] - Gloves
[A] - Apron
[R] - Respiratory protection
[N] - None

APPENDIX A

4.5 Other Bath Related Activities

Complete the following table for any other bath related activities that your facility engages in.

BATH TYPE	TYPE OF ACTIVITY (Describe)	FREQUENCY ^a	DURATION OF ACTIVITY ^b	NUMBER OF PEOPLE ^c	PROTECTIVE EQUIPMENT
CLEANER/ CONDITIONER					
PRE-DIP					
CATALYST					
ACCELERATOR					
ENHANCER					
POST-CLEAN ETCH					
ANTI-TARNISH/ ANTI-OXIDANT					
OTHER (specify)					

^a Frequency - Enter the average amount of time elapsed or number of panel sq. ft. processed since the last time the activity was performed. Clearly specify units (e.g., hours, square feet, etc.).

^b Duration of Activity - Enter the average time for performing the specified activity. Clearly specify units.

^c Personal Protect. Equip. - Consult key on the previous page and enter the letters for all protective equipment worn by the people performing the activity.

A.4 Supplier Data Sheet

DfE Printed Wiring Board Project Alternative Technologies for Making Holes Conductive (MHC)

Manufacturer/Supplier Product Data Sheet

Manufacturer Name: _____

Address: _____

Contact: _____

Phone: _____

Fax: _____

How many alternative making holes conductive product lines will you submit for testing? _____

Please complete a Data Sheet for each product line you wish to submit for testing. In addition, if you have not already done so, please submit the material safety data sheets (MSDS), product literature, and the standard manufacturer instructions for each product line submitted.

Product Line Name: _____ Category: *

*** Categories of Product Lines:**

A. Electroless copper

B. Carbon-based

C. Graphite-based

D. Palladium-based

E. Non-formaldehyde electroless

F. Copper seed

G. Anisotropic

H. Electroless Nickel

I. Drill Smear (Lomerson)

J. Conductive inks

K. Conductive polymer

L. Other

For the product line listed above, please identify one or two facilities that are currently using the product line at which you would like your product demonstrated. Also, identify the location of the site (city, state) and whether the site is 1) a customer production site, 2) a customer test site, or 3) your own supplier testing site.

Facility 1 Name and Location: _____

Type of Site: _____

Facility Contact: _____

May we contact the facility at this time (yes or no): _____

Facility 2 Name and Location: _____

Type of Site: _____

Facility Contact: _____ Phone: _____

May we contact the facility at this time (yes or no): _____

Process Description

Process Schematic

Fill in the table below by identifying what type of making holes conductive process (e.g., electroless copper) your facility uses. Then, using the key at the bottom left of the page, identify which letter corresponds with the first bath step in your process and write that letter in the first box (see example). Continue using the key to fill in boxes for each step in your process until your entire making holes conductive process is represented. If your process step is not represented by the key below, complete the chart by writing in the name of the process step in your particular making holes conductive line. Finally, consult the process automation key at bottom right and enter the appropriate type of automation for the MHC process line. If the process is partially automated, enter the appropriate process automation letter for each step in the upper right-hand corner box (see example).

Process Automation
Letter (see key below right)

Type of Process (write in process name)	Ex. <div style="border: 1px solid black; padding: 2px; display: inline-block;">A</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">T</div>	Process Steps of Your Facility (begin here)	<div style="border: 1px solid black; padding: 5px; display: inline-block; width: 80px; height: 40px; position: relative;"> </div>
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→

Standard Bath Types		Process Automation	
[A] - Center	[L] - Carbon	Type of Process Automation for Entire MHC Process (Consult the key below) If the MHC process is partially automated (option R), enter 'R' on above line. Then, for each process step in chart above, consult the key below and enter the appropriate process automation letter in the box located in the upper right hand corner of each process step (see example).	
[B] - Conditioner	[M] - Fixer		
[C] - Micro-Etch	[N] - Reducer		
[D] - Pro-dip	[P] - Air Knife/Oven	Process Automation Key [P] - Automated on-conveyorized [S] - Manually controlled hoist [Q] - Automated conveyorized [T] - Manual (no information) [R] - Partially automated [A] - All of the above [V] - Other (specify)	
[E] - Catalyst	[Q] - High pressure water		
[F] - Activator	[R] - Neutralizer		
[G] - Accelerator	[S] - Anti-tarnish		
[H] - Enhancer	[W] - Water rinse		
[J] - Electroless Copper	[O] - Other (specify step)		
[K] - Graphite			

Product Line Name _____

Please fill in the following table (for bath listings, please refer back to your process description on page 2):

Baths — Chemical Composition	Chemical Composition/Characteristics of Spent Bath^a	Standard Container Size
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
Comments:		
^a Do not include drag-out.		

Special Product Characteristics

1. Does the process operate as a vertical process, horizontal process, or either? _____
2. Is the process pattern-plate or panel-plate? _____
3. Does the process require scrubbing of panel after completion? _____
4. Does the process require spray etch, scrub, or high-pressure rinse before imaging or electroplating? If so, which? _____
5. Are there any limitations for the acid copper plating process (e.g., pattern microetch, tank configuration, ASF)? Please explain.

6. Are there any constraints on hold times as a result of the MHC process? _____

7. Please state cycle time. _____
8. Please describe any special process equipment recommended (e.g. high pressure rinse, air knife, dryer, aging equipment, etc.). _____

Product Line Constraints

1. Please list substrate compatibilities (e.g. BT, cyanate ester, Teflon, Kevlar, copper invar copper, polyethylene, other [specify]). _____
2. Please list compatibilities with drilling techniques. _____

3. Please list compatibilities with desmear processes (e.g. neutralization after permanganate, plasma, etc.).

4. List range of aspect ratio capacity. _____
5. List range of hole sizes. _____
6. List recommended oxide processes. _____

Other general comments about the product line (include any known impacts on other process steps).

Bath Life

Please fill in the following table (for bath listings, please refer back to your process description on page 2):

Bath	Recommended Treatment/ Disposal Method^a	Criteria for Dumping Bath^b (e.g., time, ft ² of panel processed, conductivity, etc.)	Recommended Bath Life
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

^a Attach and reference additional materials, if necessary

Please specify criteria for calculation in the space below:

APPENDIX A**Costs:**

Fill in the price of your product for each facility category.

	Estimated manufacturer price of product line to be tested based on recommended bath life*			
		Chemical cost per square foot panel per day	Equipment cost per square foot panel per day	Water use (gallons per minute)
Horizontal Process	Low-level throughput shop ^a			
	Medium-level throughput shop ^b			
	High-level throughput shop ^c			
Vertical Process	Low-level throughput shop			
	Medium-level throughput shop			
	High-level throughput shop			
Other (specify)	Low-level throughput shop			
	Medium-level throughput shop			
	High-level throughput shop			

^a 2,000 surface square feet per day; 18" x 24" panel = 6 square feet

^b 6,000 surface square feet per day

^c 15,000 surface square feet per day

* Please include a description of the basis for your estimates (including assumptions about holes sizes, dragout, replenishment/replacement times, equipment life, and frequencies) in the space below.

Cost Estimate Calculation: